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The Effect of Tracheostomy Timing on Clinical Outcomes in Children

Çocuklarda Trakeostomi Zamanlamasının Klinik Sonuçlara Etkisi

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Abstract

Introduction: Optimal timing for tracheostomy in children is not well defined. Our aim is to examine the pre-tracheostomy morbidities, indications and association of early tracheostomy on clinical outcomes.

Methods: This retrospective cohort study included all patients who underwent tracheostomy in the Dokuz Eylül University Pediatric Intensive Care Unit (ICU) between January 2012 and September 2020. We categorized patients into the early and late tracheostomy groups according to time on a mechanical ventilator before tracheostomy using a cut-off of 14 days. Pre-tracheostomy morbidities [ventilator associated pneumonia (VAP), central line associated bloodstream infection], indications and clinical outcomes (including length of ICU and hospital stay, incidence of VAP and mortality) were compared between early and late groups.

Results: Of the 104 patients undergone tracheostomy, 90 were included in the study: Thirty patients in the early group, 60 patients in the late group. Tracheostomy rate of our unit was 6.06%, with a median ventilator time before tracheostomy of 20 days. VAP and lung tissue disease indication for tracheostomy independently increased pre-tracheostomy mechanical ventilation time by 8 and 12.6 days, respectively. There was no statistically significant difference in VAP rate after tracheostomy, successful decannulation and mortality between early and late group. Early group had lower post-tracheostomy ICU-length of stay (LOS) (8.5 vs. 13 days p=0.041) and total ICU-LOS (17.5 vs. 45 days p<0.001). Controlling for age, tracheostomy indication, central line associated bloodstream infection and VAP; tracheostomy timing was independently associated with ICU-LOS. Late tracheostomy timing increased the ICU-LOS by 10.7 days (p=0.041).

Conclusion: Our results suggest that early timing of tracheostomy is associated with reduced ICU-LOS and VAP in children, consistent with the current literature.

Keywords: Tracheostomy, pediatric intensive care unit, ventilator associated pneumonia

Öz

Giriş: Çocuklarda trakeostomi için optimal zamanlama net olarak tanımlanmamıştır. Çalışmamızın amacı trakeostomi zamanlamasının, trakeostomi öncesi morbiditeler, endikasyonlar ve klinik sonuçlarla ilişkisinin incelenmesidir.

Yöntemler: Bu geriye dönük kohort çalışmasına, Ocak 2012-Eylül 2020 tarihleri arasında Dokuz Eylül Üniversitesi Çocuk Yoğun Bakım Ünitesi'nde (ÇYBÜ) trakeostomi açılan hastalar dahil edildi. Hastalar trakeostomi öncesi mekanik ventilatörde geçen zaman değerlendirilerek 14 günlük sınıra göre erken ve geç trakeostomi gruplarına ayrıldı. Erken ve geç gruplar arasında trakeostomi öncesi morbiditeler [ventilatör ile ilişkili pnömoni (VİP), santral venöz kateter ilişkili kan dolaşımı enfeksiyonu], endikasyonlar ve klinik sonuçlar (YBÜ ve hastanede yatış süresi, ventilatörle ilişkili pnömoni sıklığı ve mortalite) karşılaştırıldı.

Bulgular: Trakeostomi açılan 104 hastadan 90'ı çalışmaya dahil edildi: erken grupta 30 hasta, geç grupta 60 hasta vardı. Ünitemizin trakeostomi oranı %6,06, trakeostomi öncesi ortanca ventilatör süresi 20 gün idi. VİP ve akciğer hastalığı endikasyonu ile trakestomi açılmış olması, trakeostomi öncesi mekanik ventilasyon süresinde artış ile ilişkili saptandı (8, 12,6 gün p<0,05). Trakeostomi sonrası VİP oranı, başarılı dekanülasyon ve mortalite açısından erken ve geç grup arasında istatistiksel olarak anlamlı fark yoktu. Erken grupta trakeostomi sonrası YBÜ yatış süresi (8,5'e 13 gün p=0,041) ve toplam YBÜ yatış süresi (17,5'e 45 gün p<0,001) daha düşüktü. Yaş, trakeostomi endikasyonu, santral venöz kateter ilişkili kan dolaşımı enfeksiyonu ve VİP için kontrol edildikten sonra; trakeostomi zamanlaması bağımsız olarak YBÜ yatış süresi ile ilişkilendirildi. Geç trakeostomi zamanlaması YBÜ yatış süresinde 10,7 gün artış ile ilişkili bulundu (p=0,041).

Sonuç: Çalışmamızın sonuçları, mevcut literatürle uyumlu olarak, trakeostominin erken zamanlamasının çocuklarda YBÜ yatış süresi ve VİP'nin azalması ile ilişkili olduğunu göstermektedir.

Anahtar Kelimeler: Trakeostomi, çocuk yoğun bakım, ventilatör ilişkili pnömoni

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Introduction

Children with complex neurological, cardiovascular, and respiratory diseases survive longer by virtue of development on new treatment modalities and revolutionized critical care.[1,2] These children often require long-term mechanical ventilation and pulmonary secretion clearance. Tracheostomy provides an alternative airway to orotracheal intubation in prolonged ventilation in the intensive care units (ICU). It has benefits over orotracheal intubation, including; improving oral hygiene, oral intake and speech; decreasing need for analgesia and sedation; enhancing pulmonary secretion clearance.[3,4] Although tracheostomy is a complex procedure and has procedure-related complications,[5] rate of tracheostomy is increasing in both adult and pediatric ICUs with the help of improvements in technique.[3,6] The rate of tracheostomy in critically ill adult patients ranges between 10-24%, median time to tracheostomy is reported between 9-12 days.[7-9] In the pediatric population, studies demonstrated a rate of tracheostomy between 1.5-8.5% with timing of tracheostomy between 4 and 32 days.[10-13] The optimal timing of tracheostomy is unclear in critically ill patients. Early tracheostomy in adults (≤10 days after tracheal intubation) is associated with a higher number of ventilator-free days, reduced ICU stays, lower long-term mortality.[14] Several studies have defined early timing of tracheostomy in PICU as 10 to 14 days after tracheal intubation and demonstrated that early tracheostomy was associated with reduced duration of mechanical ventilation, ICU and hospital stay, ventilator-associated pneumonia (VAP) rate.[15-17] In this study, we hypothesized that early tracheostomy (≤14 days after tracheal intubation) in children is associated with reduced ICU and hospital length of stay (LOS), VAP rate and mortality.

Materials and Methods

This study protocol was approved by the Ethics Committee of the Dokuz Eylül University Faculty of Medicine (5837-GOA-2020/28-01). We conducted a retrospective cohort study including all children admitted to our pediatric ICU who underwent tracheostomy between January 2013 and September 2020. Our PICU is a 6-bed ICU in a tertiary-care children's hospital, accepting children between 1 month-18 years of age with medical, surgical, oncological and trauma indications. We excluded patients who had tracheostomy procedure or decision before PICU admission, whose tracheostomy was performed emergently and who had no invasive ventilation before tracheostomy. Tracheostomy decisions were made on individual cases after discussing with attending and otolaryngologists. All tracheostomies were performed by open surgical technique in the operation room by the same otolaryngology team. Medical and personal records of all patients were extracted from electronical records. A standard data extraction form was prepared. Demographic and clinical data were collected from each patient, including gender, age, pediatric index of mortality 3 (PIM3), the primary reason for admission, indication for tracheostomy, duration of mechanical ventilation, length of PICU and hospital stay, VAP, central line-associated bloodstream infection (CLABSI), mortality and successful decannulation. We defined CLABSI and VAP according to CDC definition (www.cdc.gov, accessed January 12, 2021).

Early tracheostomy is defined as tracheostomies performed within 14 days of mechanical ventilation. Tracheostomies performed after 14th day of mechanical ventilation are defined as late tracheostomy. Since there is no guideline indicating optimal timing of tracheostomy in prolonged ventilation in critically ill children, we set 14 days threshold based on previous clinical studies.[16,17]

The primary reason for PICU admission was divided into 9 categories: 1) respiratory; 2) neurological; 3) cardiovascular; 4) metabolic; 5) trauma; 6) oncological; 7) post-operative (cardiac surgery); 8) post-operative (other); 9) other. Tracheostomy indication was divided into 4 categories: 1) lung tissue disease; 2) disordered control of breathing (neurological and neuromuscular diseases); 3) cardiovascular disease; 4) airway obstruction.

Statistical Analysis

Continuous non-normally distributed data were compared by Mann-Whitney U test, expressed as median (interquartile range). Multivariate regression was conducted to analyze confounders of PICU LOS and pre-tracheostomy mechanical ventilator days. Categorical variables were analyzed by chi-square or Fisher's Exact test. All tests were two tailed, and a p-value of less than 0.05 was taken as statistically significant. SPSS 22.0 software (SPSS, Chicago, IL) was used for data analysis.

Results

Of the 1714 patients admitted to PICU between January 2012 and September 2020, 104 underwent tracheostomy. We excluded 14 patients: Nine patients had no invasive ventilation before tracheostomy, three patients underwent urgent tracheostomy, and two patients were transferred to another hospital. Ninety patients were included for statistical analysis: Thirty patients were included in the early group; 60 patients were included in the late group. Tracheostomy rate of our PICU was 6.06% with a median mechanical ventilation time before a tracheostomy of 20 (11, 34.25) days. The characteristics of

the total 90 patients are shown in Table 1. Age, gender, PIM3 score, need for vasoactive drug, reason for admission to PICU and underlying diseases did not differ significantly between the early and late groups. However, patients who underwent tracheostomy due to disordered control of breathing were significantly higher in early group (p=0.004), whereas patients with lung tissue disease were higher in the late group (p<0.001). Median mechanical ventilation time of patients with lung tissue disease indication and disordered control of breathing indication were 38 days and 15 days, respectively. Among the factors affecting mechanical ventilation duration before tracheostomy, 41 patients had CLABSI, 40 patients had VAP. Multivariate regression analysis of pre-tracheostomy factors demonstrated that VAP and lung tissue disease indication for tracheostomy increased pre-tracheostomy mechanical ventilation days independently (Table 2). Age, gender and PIM3 were not associated with pre-tracheostomy ventilator days.

Table 3 shows the comparison of clinical outcomes of the early and late groups after tracheostomy. There was no significant change between the early and late groups in hospital LOS after tracheostomy. However early tracheostomy group had lower post-tracheostomy ICU LOS (p=0.041) and total ICU LOS (p<0.001). VAP rate was significantly lower in the early group (p=0.003). There was no statistically significant difference in VAP rate after tracheostomy, successful decannulation and ICU mortality between the early and late groups.

The factors affecting length of ICU stay were analyzed using multivariate regression analysis (Table 4). Controlling for age, tracheostomy indication, CLABSI and VAP, tracheostomy timing was independently associated with ICU-LOS. Late tracheostomy increased the ICU-LOS by 10.7 days (p=0.041).

Table 1. Demographics, primary diagnosis, tracheostomy indications of patients

	All (n=90)	Early tracheostomy (n=30)	Late tracheostomy (n=60)	p
Age (month)	11 (5, 87)	22 (5, 126)	10 (4, 84)	0.353
Male gender	55 (61)	19 (63)	36 (60)	0.760
Primary reason for PICU admission				
Respiratory	68 (75.6)	24 (80)	44 (73.3)	0.488
Neurological	6 (6.7)	1 (3.3)	5 (8.3)	0.659
Cardiovascular	7 (7.8)	1 (3.3)	6 (10)	0.417
Trauma	7 (7.8)	4 (13.3)	3 (5)	0.216
Other	2 (2.2)	0	2 (3.4)	1.000
Underlying disease				
Neurological	53 (58.9)	18 (60)	35 (58.3)	0.532
Cardiovascular	11 (12.2)	3 (10)	8 (13.3)	0.467
Cancer	3 (3.3)	0 (0)	3 (5)	0.291
Tracheostomy indication				
Lung disease	30 (33.3)	2 (6.7)	28 (46.7)	<0.001
Neurological impairment	46 (51.1)	22 (73.3)	24 (40)	0.004
Airway obstruction	10 (11.1)	6 (20)	4 (6.7)	0.078
Cardiovascular disease	4 (4.4)	0	4 (6.7)	0.297
Need for vasoactive drug	14 (15)	4 (13.3)	10 (16.6)	0.469
PIM 3	7.88 (5.54, 12.74)	7.17 (3.40, 11.37)	9 (6.10, 13.06)	0.107

Values are expressed as median (interquartile range) or number (%)

Table 2. Multivariate regression analysis of pre-tracheostomy factors and pre-tracheostomy mechanical ventilator days

Factors	Regression Coefficient	95% CI	p
CLABSI before tracheostomy	2.64	-2.86 to 8.15	0.343
VAP before tracheostomy	8	2.37-13.64	0.006
Chronic lung tissue disease	12.62	4.28-20.97	0.003
Neurological impairment	-4.96	-12.76 to 2.85	0.21

CLABSI: Central line-associated bloodstream infection, VAP: Ventilator associated pneumonia, CI: Confidence interval

Table 3. Comparison of clinical outcomes between early and late tracheostomy group

	Early tracheostomy (n=30)	Late tracheostomy (n=60)	p
Total length of ICU stay (day)	17.5 (14, 24)	45 (32, 59)	<0.001
Length of ICU stay after tracheostomy (day)	8.5 (7, 12)	13 (7, 19)	0.041
Length of hospital stay after tracheostomy (day)	45 (21, 100)	47.5 (27, 66)	0.691
VAP during ICU stay	8 (26.7)	36 (60)	0.003
VAP after tracheostomy	5 (16.7)	10 (16.7)	1.000
Successful decannulation	8 (26.7)	11 (18.3)	0.361
ICU mortality	1 (3.3)	2 (3.3)	1.000

Values are expressed as median (interquartile range) or number (%). ICU: Intensive care unit, VAP: Ventilator associated pneumonia

Table 4. Multivariate logistic regression analysis for predictors of VAP

Predictors	Odds ratio (95% CI)	p
Age (month)	1.004 (0.996, 1.012)	0.296
Late tracheostomy	4.506 (1.448, 14.022)	0.009
Central line associated bloodstream infection	2.588 (0.976, 6.86)	0.056
Urinary tract infection	2.170 (0.802,5.872)	0.127
Tracheostomy indication: Lung disease	0.758 (0.170, 3.389)	0.717
Tracheostomy indication: Neurological impairment	0.608 (0.151, 2.449)	0.608

CI: Confidence interval, VAP: Ventilator associated pneumonia

Table 5. Multivariate regression analysis of pre-tracheostomy factors and length of ICU stay

Variables	Regression Coefficient	95% CI	p
Age at tracheostomy	-0.06	(-0.123, 0.003)	0.06
Late tracheostomy	10.05	(0.417, 19,674)	0.041
CLABSI before tracheostomy	4.99	(-3.30, 13.29)	0.235
VAP before tracheostomy	13.73	(9.78, 20.61)	0.002
Chronic lung tissue disease	10.69	(-2.16, 23.54)	0.102
Neurological impairment	-11.08	(-22.94, 0.78)	0.067

CI: Confidence interval, CLABSI: Central line-associated bloodstream infection, VAP: Ventilator associated pneumonia, ICU: Intensive care unit

Discussion

In our pediatric ICU, 104 of 1714 patients undergone tracheostomy. Tracheostomy rate of our PICU was 6.06%, slightly higher than the current literature.[10,11,18] Median ventilator days of patients before tracheostomy was 20 days, representing an ordinary timing compared to recent studies.[11,17]

Although 75% of patients were admitted to PICU primary due to respiratory diseases, the indication for tracheostomy was predominantly disordered control of breathing (neurological and neuromuscular diseases). This high rate of neurological indication in our cohort could be explained by the large number of patients with neurometabolic disease being referred to our hospital since it is a regional referral center. Tracheostomy performed with a lung tissue disease indication was significantly higher in the late group whereas disordered control of breathing was higher in early group. These findings indicate that our multidisciplinary team consisting of intensive care physicians and otolaryngologists reached a consensus on tracheostomy indication earlier in neurological patients requiring invasive ventilation.

Among the morbidities in the ICU, VAP and CLABSI was demonstrated to increase ventilation time before tracheostomy by 16.5 and 12.7 days respectively.[17] Similarly, in our study we demonstrated that VAP before tracheostomy increased mechanical ventilation time by 8 days. These increased ventilator days could be explained by our team waiting for a longer period for recovery of pulmonary functions following appropriate antibiotic therapy. Pizza et al.[15] demonstrated that VAP rate after tracheostomy was significantly lower in the early group, unlike other studies.[16,17,19] We examined VAP

rate after tracheostomy as a clinical outcome, there was no significant difference between the early and late groups.

Controlling for CLABSI and VAP, tracheostomy indication of lung tissue disease increased pre-tracheostomy mechanical ventilation time by 12.6 days. In a recent study, indication for tracheostomy was not statistically significant between early and late group.[16] This result suggests that our team waits for a longer period for successful extubation in patients with primary lung tissue disorders, to avoid complications of tracheostomy procedure.

Several studies have demonstrated that early tracheostomy was associated with decreased ICU and hospital LOS, mechanical ventilator days.[16,17,20] In our study, patients in the early group had 4.5 lower post-tracheostomy ICU days, 27.5 days lower total ICU days. We evaluated factors affecting ICU LOS, including age, CLABSI, VAP, tracheostomy indication and timing of tracheostomy; timing of tracheostomy and VAP were independently related to ICU LOS. The late tracheostomy group had 10 more ICU days; children having at least one VAP diagnosis had 13.7 more ICU days after adjusting for other factors. Although we were unable to demonstrate a significant difference in hospital LOS; decreasing the need for prolonged ICU stay reduces ICU-related morbidities and medical cost. Additionally, reducing ICU LOS of critically ill children leads to use ICU beds more efficiently in resource limited clinical settings.

Our study showed no significant difference in PICU mortality between the early and late tracheostomy groups. Our data are consistent with current literature, which shows no significant association between timing of tracheostomy and mortality.[15,16,21]

Study Limitations

Our study has several limitations. Retrospective design of the study made it impossible to randomize patients into the early and late groups. Patients in early and late groups were heterogeneous in tracheostomy indications. The causative relationship between ICU morbidities and delayed tracheostomy timing could not be explained due to retrospective design of the study. Our sample size was not sufficient to analyze outcomes in subgroups. Finally, we were unable to control the factors affecting length of hospital stay after transfer from PICU to inpatient ward.

Conclusion

Our study suggests that early timing of tracheostomy is associated with decreased ICU stay with no significant difference in mortality. We observed a relation between timing of tracheostomy and VAP rate however, further studies in a prospective fashion are needed to analyze causative relationship between ICU morbidities and delayed tracheostomy timing.

Ethics

Ethics Committee Approval: This study protocol was approved by Ethics Committee of the Dokuz Eylül University Faculty of Medicine (5837-GOA-2020/28-01).

Informed Consent: Retrospective study.

Peer-review: Internally and externally peer-reviewed.

Authorship Contributions

Concept: T.B., G.A., M.D., Design: T.B., G.A., M.D., Data Collection or Processing: T.B., G.Ö., G.E., T.A., Analysis or Interpretation: T.B., G.A., T.A., M.D., Literature Search: T.B., G.Ö., G.E., G.A., M.D., Writing: T.B., G.A., M.D.

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